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THE VERTICAL DRIER FOR SEED COTTON [1]

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CONTENTS

NEED FOR SEED-COTTON DRIERS

Plantations and ginning plants frequently lack facilities for storing seed cotton in quantities or drying it artificially. Usually the first pickings require drying on account of the sticky condition of the cotton, while much of the late-picked cotton is dampened by rains. Any successful drying process must make it possible to handle freshly harvested cotton, whether from the early crop or from the final pickings of the season.

The average battery of four 80-saw gin stands handles about 100 pounds of seed cotton per minute, and the process and equipment described in this publication have been worked out to provide a simple and dependable installation that will dry sufficient seed cotton at a continuous rate to prevent interruptions in ginning caused by wide variations of weather and of moisture condition in the cotton. Capacity ample to supply a commercial ginning plant of five 80-saw gins is also feasible.

The growing recognition of the benefit [3] that may be derived from drying damp or wet seed cotton with the vertical seed-cotton drier developed by the United States Department of Agriculture [4] has

[1] This publication supersedes Miscellaneous Publication No. 149, The Vertical Seed-Cotton Drier.

[2] Acknowledgment is made to Boardman Co., Fairbanks-Morse Co., Gullett Gin Co., Lummus Cotton Gin Co., B. F. Sturtevant Co., and others for their cooperation with the U. S. Department of Agriculture in supplying some of the information contained in this publication.

[3] See the following publication: Gerdes, F. L., and Bennett, C. A.: effect of artificially drying seed cotton before ginning on certain quality elements of the lint and seed and on the operation of the gin stand. U. S. Dept. Agr. Tech. Bull. 508. (In press.)

[4] Bennett, C. A. an apparatus for drying seed-cotton. U. S. Patent No. 1,871,773, filed July 30, 1931; issued Aug. 16, 1932. U. S. Patent Office Off. Gaz. 421: 670, illus. 1932.

contributed to the manifest interest in and the rapidly increasing use of this drier.

Investigations to develop effective and economical means for drying damp seed cotton so as to make ginning easier were begun by engineers of the Department in 1926. Various types of apparatus were built and tested, including both horizontal and vertical drying chambers with trays or baskets on endless chains to carry the cotton and with belt or apron conveyors. A drier with a horizontal drying chamber 24 to 32 feet long with four or six sheet-metal floors along which the seed cotton was dragged by skeleton conveyors while exposed to a flow of heated air was found practical, but soon was succeeded by the vertical type described in this publication. In this type the drying chamber contains no moving parts and the seed cotton is carried through it by the blast of drying air. Because of the simplicity of this design, it is more economical to construct and to operate than the earlier types. Moreover, to an appreciable degree this type automatically adjusts the period of exposure in the drying chamber to the degree of dampness of the cotton, because that which has little moisture moves through the chamber more quickly than that which has much moisture. This drier has proved satisfactory in actual service under wide variations in conditions.

THE GOVERNMENT PROCESS FOR DRYING SEED COTTON

In its investigations of means for artificially drying seed cotton the Bureau of Agricultural Engineering developed and patented a process that has come to be known as "the Government process", which may be used with several types of apparatus. This process involves the following features: (1) The damp seed cotton is treated with a continuous current of hot air, at the rate of from 40 to 100 cubic feet of hot air for each pound; (2) the cotton is exposed to the drying process for different periods, usually from 15 seconds to 3 minutes, depending on the design of the drying apparatus; (3) the temperature of the drying air should preferably be between 150° and 160° F. for cotton handled during the early part of the ginning season, although temperatures as high as 200° have been used satisfactorily with late-season wet cotton. Tests have indicated that these temperatures have no unfavorable effect on the lint or on the planting quality of the cottonseed.

This process of drying seed cotton is used successfully not only in the vertical drier designed by Department engineers and described in this publication, but also in other types of driers designed by manufacturers of ginning machinery in which the drying is done in horizontal revolving cylinders or combined with the operations of distributing, cleaning, or extracting.

In the experiments that developed the Government process it was found that to assure satisfactory ginning the moisture content of the damp or wet seed cotton should be reduced so that the moisture in the lint would produce reactions like those produced by the moisture in lint from seed cotton containing 8 to 12 percent moisture. In most cases this condition was obtained by removing about 3 pounds of moisture per 100 pounds of damp seed cotton. The experiment also showed heated air to be the most practical drying medium for this material.

Many variable factors enter into the functioning of a cotton drier, causing each design of drying apparatus to produce individual drying effects which reflect its combination of the influences of the hot-blast volume, the period of exposure, and the temperature of the drying medium as it enters and leaves the drier.

To meet the requirements of the process developed by the United States Department of Agriculture, a cotton drier should (1) insure safety to fiber and seed, (2) treat uniformly all portions of the seed cotton from the first to the last of a load, (3) be adaptable to existing ginning plants without requiring special installation lay-outs for each gin, and (4) be so constructed that all the parts are readily accessible, dependable, easy to operate, of ample capacity, and reasonable in cost.

CONSTRUCTION OF THE VERTICAL DRIER

The vertical drier described in this publication has no moving parts within the drying chamber and will readily dry cotton that does not

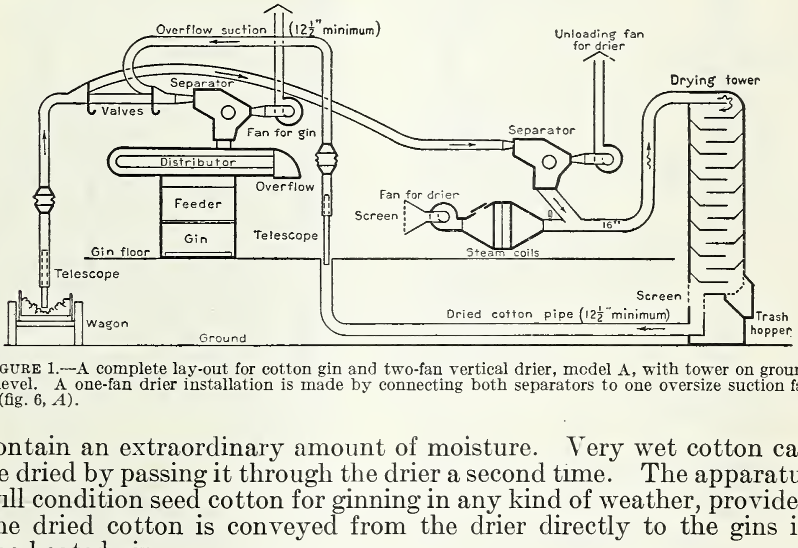

FIGURE 1.—A complete lay-out for cotton gin and two-fan vertical drier, model A, with tower on ground level. A one-fan drier installation is made by connecting both separators to one oversize suction fan (fig. 6, *A*).

contain an extraordinary amount of moisture. Very wet cotton can be dried by passing it through the drier a second time. The apparatus will condition seed cotton for ginning in any kind of weather, provided the dried cotton is conveyed from the drier directly to the gins in the heated air.

The space required for the drier is not too great to permit installation in connection with cotton gins of standard widths and heights. The tower may be placed either within the gin building or out of doors, as its construction is suitable for either location, but the steam coils, fans, and feeding equipment always are sheltered within the gin building so that they are accessible to the ginner at all times.

The manner in which the earliest installations of the vertical drier were connected to the gin, and now designated as model A, is shown diagrammatically in figure 1. As indicated, the seed cotton is fed pneumatically through the wagon telescope to the separator that deposits the cotton in the hot blast created by the drier fan, which blows (or draws) air over heated coils. This hot air travels through the drying tower at approximately 800 to 1,200 linear feet per minute. The locks of cotton impinge violently upon the warm sheet-metal walls of the tower at each reversal of direction from floor to floor.

From the bottom floor of the tower, the dried cotton is thrown against the cleaning screen where some of the foreign matter is cast out, after which the cotton is carried in an envelope of hot air to the gins. The following pages give details of construction by which the model A drier can be built with the class of labor ordinarily available about cotton gins and plantations.

The tower may be installed either on the ground floor as shown in figure 1 or above the ginning equipment in such a manner as to discharge the cotton into the distributor or the cleaning machinery by gravity. Construction details are the same for either installation except with regard to the funnel outlet, as shown in figure 2. With

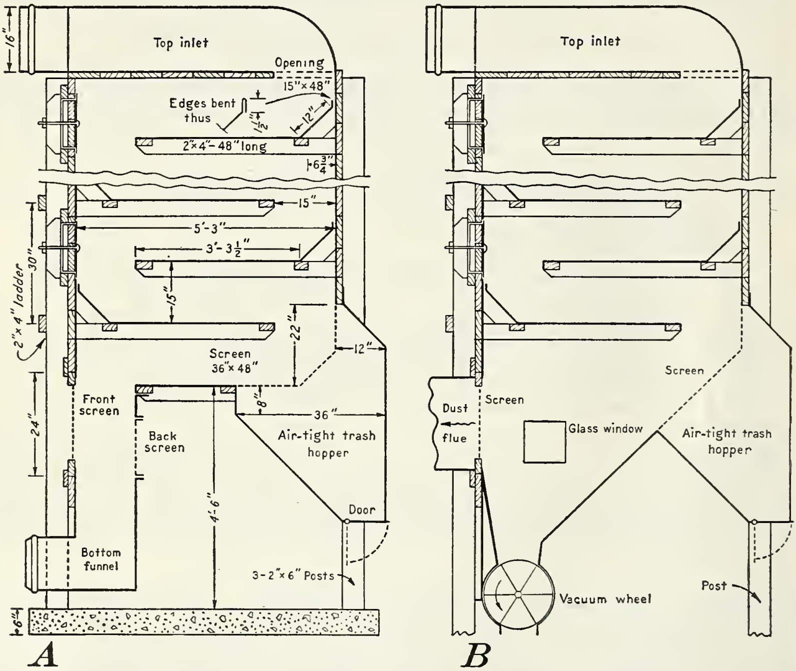

FIGURE 2.—Construction details of ground level (*A*) and elevated (*B*) drying towers.

the elevated tower lay-out, the separator of the ginning system may, in many instances, serve the drier also, because the overflow of the gin does not need to be connected to the drier as must be done for the ground-level installation. An elevated tower is generally impractical for a two-story ginning plant because of the excessive height.

In the drying tower are 13 to 20 stationary sheet-metal floors carried on 2- by 4-inch wooden frames. In general, 17 floors provide ample exposure of the seed cotton to the drying process. In the shorter staple cotton areas the number of floors may be less than 17 if the cotton to be handled is not too wet. Where heavy fogs are prevalent, 19 or 20 floors may be advisable. Two floors more than the minimum necessary add but little to the cost. With an odd number of floors both top-inlet and bottom-outlet piping connections

will be on the front of the drier; with an even number of floors the bottom outlet will be at the back of the tower.

The heights of towers, including the top inlet, for various numbers of floors, are as follows:

Number of floors:	Total height of tower Feet	Inches
13	22	1
14	23	4
15	24	7
16	25	10
17	27	1
18	28	4
19	29	7
20	30	10

An approximate bill of materials for a 17-floor tower is given in table 1. The plan dimensions of the tower are 5 feet 3 inches by 4 feet 0 inches, inside.

TABLE 1.—*Approximate bill of material for a 17-floor vertical seed-cotton drying tower*

Description	Use	Quantity
Galvanized cotton piping, 16-inch and smaller	See drawings	(1)
Steam pipe, valves, etc	do	(1)
Sheet-metal top inlet	On top of tower	1
Sheet-metal bottom funnel	At bottom of tower	1
Fine intake screen	At steam coils	1
Heavy outlet screens, ½-inch mesh	At bottom of tower	2
2- by 6-inch by 14-foot yellow pine lumber	Corner posts of tower	24
2- by 8-inch by 14-foot yellow pine (to be cut)	Sides of tower	40
2- by 8-inch by 16-foot yellow pine (to be cut)	Front and back of tower	22
2- by 8-inch by 10-foot yellow pine (to be cut)	Top of tower	4
2- by 4-inch by 12-foot yellow pine (to be cut)	Ladder, etc	6
No. 28 galvanized plates, 48 by 96 inches	Front and back lining of tower	6
No. 28 galvanized plates, 48 by 72 inches	Lining sides of tower	12
No. 22 galvanized plates, 48 by 60 inches	Tower floors	17
½- by 7-inch carriage bolts and washers	Handholes in tower	16
2- by 4-inch by 4-foot yellow pine lumber	Floor supports	68
2- by 4-inch by 1-foot yellow pine lumber	Incline supports	34
Sixteenpenny common nails		(2)
Eightpenny common nails		(2)

1 As required. 2 1 keg.

The side walls of the tower are lined with flat sheets of no. 28 galvanized iron and the floors are spaced 15 inches apart, as shown in figure 2. The floors should be of no. 22 galvanized sheet iron or heavier. For the drier foundation, a concrete slab 7 feet long and 5 feet wide is desirable. Handholes should be placed in the front of the tower opposite alternate floors to permit inspection and easy cleaning. Details of these handholes are shown in figure 3. A ladder on the front of the tower makes it easy to reach any handhole.

In constructing the tower for ground-level installation, it is frequently possible to build the front and back of the tower on the ground, complete with the handholes, and face them with galvanized sheet metal; then raise them to a vertical position and build up the sides. Usually the elevated tower, and sometimes the ground-level tower, must be built into place to suit the particular conditions.

The sills and crosspieces for the floors are usually built in as the side walls are built up. This is a very simple method of construction, because planks can be placed on the floor frames to form scaffolding.

The floor supports and incline pieces may be either spiked or bolted to the sides and ends of the tower, and the metal and floor incline sheets should be carefully nailed to them. The floors are laid and secured in turn, commencing with the lowest, and a top of 2-inch planking completes the carpentry work on the tower.

All upper edges of the floor sheets and of the metal facing on the handholes should be beaded back into a return bend, having a round, smooth edge so that no cotton will be caught in passing through the drier. No nails smaller than eightpenny should be used in securing the galvanized lining and floor sheets, and where the nails go through the siding they should be clinched.

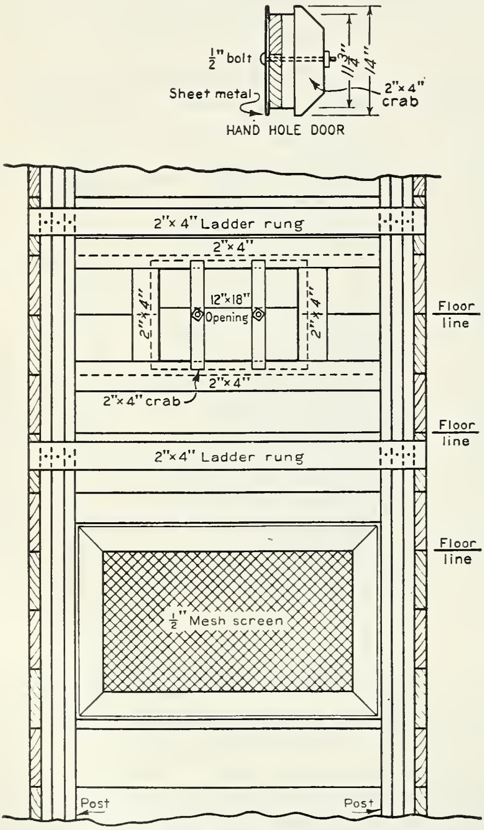

FIGURE 3.—Lower portion of front of tower, and handhole door.

The top of the tower is then fitted with the top inlet of no. 22 galvanized sheet steel, which forms the hood where the hot air and damp cotton are delivered into the drier, as shown in figure 4. The top inlet is flared out and increased in area to slow down the hot-air currents so that their velocity will be just sufficient to carry the damp cotton from floor to floor, tumbling and drying it as it goes. The hot-air current keeps the cotton moving. A 1-inch steam line should be led to the 16-inch hot-blast pipe for use in case of fire. If the drier tower is exposed to the weather, it will be necessary to insulate and cover the top inlet to conserve heat.

After the floors have been secured in the tower, the bottom funnel should be nailed in position. Various shapes of funnels may be used; figure 5 indicates, by dotted lines, a side outlet as alternative to the front opening. The diameter may be varied to suit the gin suction, but is usually 12½ or 13 inches. Figure 2 shows the funnel construction recommended for elevated-tower connection.

The screens in the openings at the front and the back of the bottom funnel (figs. 2 and 3) should be easily removable for access into the bottom funnel. They may be of perforated plate. In ground-level installations they act as equalizers between the hot-blast fan of the drier and the regular suction fan of the gin, permitting a wide varia-

tion in the capacities of the fans and preventing a bottling or corking action in the tower. During operation of the drier, a great deal of pin trash and other dirt is thrown out through the front screen.

Still further effective and cheap cleaning of the seed cotton may be accomplished in the drier by introducing a screened trash hopper as shown in figure 2. With this cleaning feature built into the tower, ginners have been able to remove significant quantities of fine trash and other foreign matter, and frequently have employed the tower without heat in midseason ginning for its cleaning effect alone. The position indicated is suitable for this hopper, because there the seed cotton is in its driest and most fluffed-up condition. The hopper should be airtight and should be emptied at intervals as required. Public patent applications have been filed upon this improvement in cotton driers, in order that its use may be free to all.

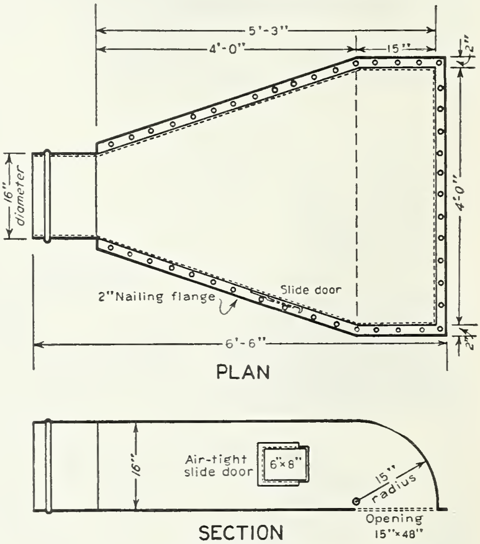

FIGURE 4.—Plan and section of top inlet for tower.

ALTERNATE METHODS FOR FEEDING THE DRIER

The standard two-fan drier installation shown in figure 1, which was developed concurrently with the invention of the vertical drier, is frequently called the "Government two-fan system." It will handle any condition of cotton, including wet, sledded, and snapped cottons. One fan unloads the seed cotton from the wagon through the separator, while another fan supplies the hot blast that carries the cotton through the drying tower. A one-fan installation, which requires only one fan for the drier in addition to that for the gin separator, provides the same method of feeding the cotton and air to the drying tower by connecting both separators to one oversize unloading fan (fig. 6, *A*). This necessitates slide dampers in the suction line, to adjust the two separator systems to the desired capacities. The dampers should be locked in position to prevent unauthorized change.

Three other methods of feeding the vertical drier have been found practical. The four methods, which characterize the different installations or models A, B, C, and D, are shown in figure 6.

Model B is privately patented. It will handle any condition of cotton. The cotton from the wagon mixes with the hot air from the heater in the Rembert-type fan. The wagon suction and the blast temperature are controlled by means of the dampers indicated and of valves on the heater. Satisfactory results can be obtained with this model if care is taken to maintain the inlet temperature of the drier slightly below that found desirable with the double-fan drier. This is particularly important, if adverse effects on fiber length are

to be avoided, because the increased volume of hot air which circulates through the tower necessitates lower temperatures than does the double-fan system. The greater volume of hot air handled at a given temperature by the single-fan system than by the double-fan method causes increased moisture removal, which action is similar to increasing the drier temperature.

Model C is employed by a manufacturer of vertical driers in a special combination with a patented heater. Dampers on the suction piping and valves on the heater control the air flow and blast temperature.

Model D was developed by Department of Agriculture engineers to obtain a home-made drying outfit dependable in operation and requiring a minimum of power. It requires a heater made of smooth iron pipe so constructed as to be easily cleaned and not subject to chokage when left unattended. It is not recommended for handling roughly harvested, sledded, or trashy snapped cotton. The suction inlet of the fan should be provided with means for affording an adequate air supply to the tower at all times, especially when the nose of the telescope is buried in the cotton wagon. Either a dampered T or a tapered cone with adjustable slots (fig. 6) may be used, because the diameter of the fan inlet is usually several inches greater than that of the suction pipe leading to it.

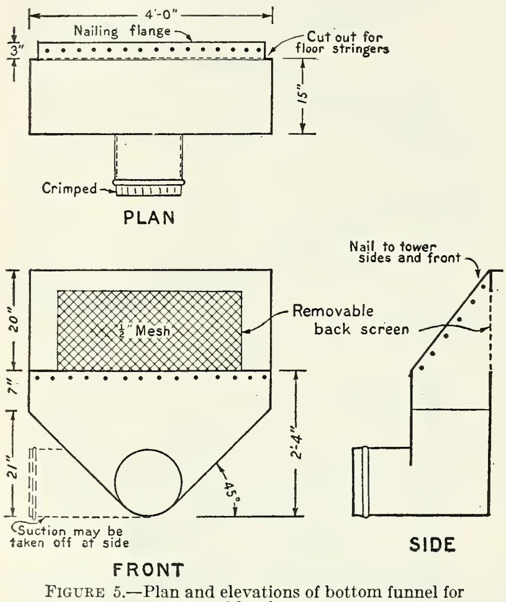

Figure 5.—Plan and elevations of bottom funnel for ground-level tower.

Fan sizes recommended for a 2-fan model A drier to serve a battery of four 80-saw gins are no. 35 for the gin and no. 40 for the drier. The one-fan installation of this model should have a large unloading fan, no. 45 running at 1,700 to 1,750 revolutions per minute when blowing seed and at 1,520 to 1,600 revolutions per minute when not blowing seed, or no. 50 running at about 1,500 revolutions per minute when blowing seed and 1,300 when not blowing seed. For the same ginning plant a no. 45–40 (Rembert-type) fan is recommended for model B installation, a no. 45 fan for model C, and a no. 40 or 45 fan for model D.

For preliminary use in selecting fans for vertical drier installations, the quantities of heated air required to remove 3 pounds of moisture per 100 pounds of seed cotton having an initial moisture content of 12 percent or more may be taken as shown in the following tabulation. These quantities have been calculated for atmospheric con-

ditions of 70° F. temperature and 75 percent relative humidity and a drier efficiency of 35 percent.

Temperature of air entering drier (° *F.*):	*Volume of air per minute (Cubic feet)*
110	13, 230
120	10, 680
130	9, 000
140	7, 875
150	6, 840
160	6, 240
170	5, 400
180	4, 824
190	4, 410
200	4, 245

In Missouri, Tennessee, and northern Arkansas the snapped cottons frequently contain whole bolls, both green and otherwise.

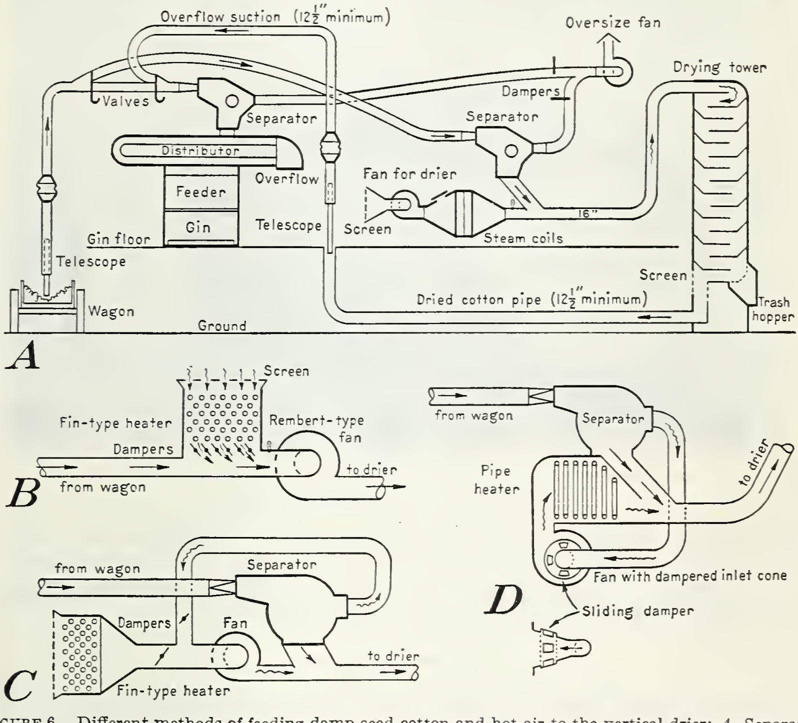

FIGURE 6.—Different methods of feeding damp seed cotton and hot air to the vertical drier: *A*, Separate fans unload the cotton and drive the hot blast (fig. 1 shows alternative arrangement); *B*, a Rembert-type fan, with split suction, serves in lieu of separator and provides both unloading suction and hot-blast drive; *C*, a split-suction model using one fan and separator; *D*, a one-fan-and-separator model using a smooth-pipe heater.

Where such unopened cotton bolls are to be handled, it is necessary to use some form of boll breaker in conjunction with the separator in drier model A or C in order to get such material dried.

ACCESSORIES OF THE VERTICAL DRIER

COTTON PIPING

The hot-blast pipe from the drier fan to the tower should preferably be 16 inches in diameter, to prevent restriction in the volume of hot air. The separator should discharge directly into the 16-inch hot-blast pipe, as shown in the illustrations, so that there will be no back lash or countercurrents to cause chokage. With the models employing a separator, a suction heel should protrude about 3 inches into the hot-blast pipe (fig. 6), as this tends to draw the cotton out of the separator and avoids chokage where the cotton enters the pipe.

Both the dry-cotton pipe from the bottom of the tower to the gin overflow floor and the overflow suction pipe, in the ground-level

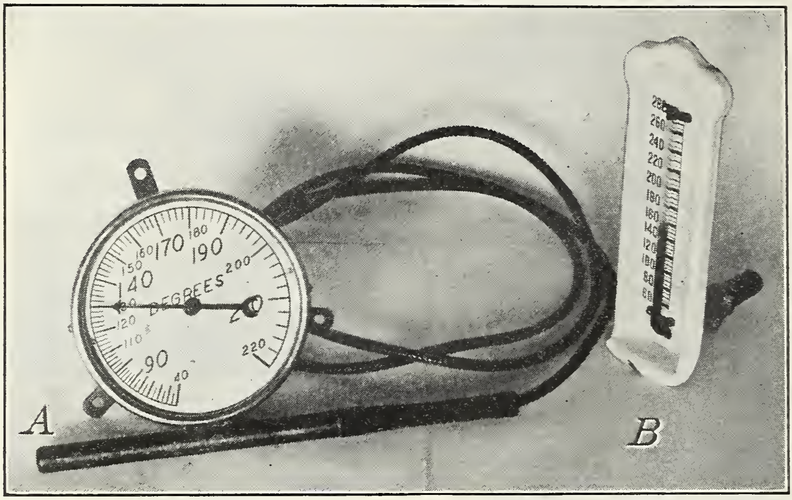

FIGURE 7.—Thermometers for cotton driers: *A*, Dial and bulb connected by flexible stem; *B*, mercury bulb in threaded metal stem, angle pattern.

installation, should be at least 12½ inches in diameter, as smaller pipes prevent rapid removal of the dried cotton from the tower.

All cotton piping leading to and from the drier should be insulated. Common sheet asbestos will serve this purpose.

THERMOMETERS

An inexpensive form of satisfactory thermometer for cotton driers is the straight or the angle mercury thermometer (fig. 7, *B*) used for steam and hot water, having protected bulb and threaded metal stem. The scale should be approximately 40° to 240° F. A more expensive kind of thermometer has flexible tubing and dial (fig. 7, *A*) so that the dial may be at some distance from the bulb. The range of such thermometers is from 40° to 220° or greater.

The thermometer should preferably be located where no seed cotton will strike its stem and thus cause vibration or breakage. When only one thermometer is employed, it should measure the temperature of the air entering the drying tower, because this temperature must be controlled within the prescribed limits of the

Government process. Location between the heater and the drier separator (fig. 6, *A*) does this satisfactorily; in model B the thermometer should be placed between the heater and the fan (fig. 6, *B*). Attempts to regulate the drier by means of thermometers placed at the drier outlet have been unsatisfactory because the variable quantities of moisture in the seed cotton produce widely different final temperatures of the moisture-laden air.

POWER REQUIREMENTS

Where model A driers are installed with the tower at ground level (figs. 1 and 6), additional power must be supplied to operate one or more fans. If both the unloading and hot-blast fans are to be electrically driven, each should be supplied with a 20-horsepower motor, but where the entire drying equipment is operated from a single motor or engine 30 to 35 horsepower is usually sufficient to run both the fans and the separator. With ginning plants having a central power unit, the necessary increase in power would not be so great, because about one-fifth less power is required by the gin stand when ginning dried seed cotton than when ginning green, damp, or wet cotton, and this saving would provide a large part of the power required to operate the drier. For the same reason model A installations comprising an elevated tower or the one-fan lay-out diagrammed in figure 6, in some cases, require very little additional power in the ginning plant. To simplify the installation, the fan should be belted from the flywheel of the engine if possible.

Where a model B or D drier is installed with the tower elevated there will be no appreciable increase in the total power needed for both the ginning system and the drier, because the Rembert-type fan of the model B drier or the fan and separator of the model D drier may replace the prior unloading outfit of the ginning system and be driven from shafting and pulleys previously used.

SOURCE OF HEAT

A 30-horsepower or larger steam boiler may be used for normal drying work, vertical boilers being preferred. Smaller coal-burning boilers have often been converted to oil burners, resulting in an increased capacity which has proved satisfactory for cotton drying. Pressure should be kept at from 50 to 100 pounds gage, and the boiler should be well covered to obtain economy of fuel. The steam coils for the drier must be placed several feet above the water line of the boiler if the condensed steam is to drain back to the boiler without traps or pumps. A check valve should be put in the return line, and a ½-inch vent valve on each coil so that the heater will not become air-bound. Each coil vent may be led through a check valve to a common automatic vent valve, but the vents from two or more sections should not be combined without the use of check valves.

Where the ginning system is operated by steam power, it is frequently feasible to utilize the low-pressure exhaust steam for the heater coils of the drier rather than incur the expense of installing an additional high-pressure boiler. To do this requires increasing the size of the heater by adding 20 percent more heating surface, and making certain changes in the piping system to prevent restriction of the engine exhaust. The steam header for supplying low-pressure

exhaust steam to the heater coils should be 4 inches or larger, and should be provided with a standard type of back-pressure or atmospheric exhaust valve that will not allow excessive back-pressure to be placed upon the engine exhaust. This back pressure may be adjusted to maintain 5 pounds steam pressure or even less for cotton-drying purposes. A small valved supply pipe from the high-pressure steam piping of the boiler is desirable in order to supply additional quantities of steam to the exhaust line when necessary. For continual use, however, a reducing valve should be employed. The use of exhaust steam in combination with the drying installation shown in figure 6 results in a practical and cheaply operated drier for a steam-powered gin.

For cotton gins having internal-combustion engines of 100 horsepower and larger, the engine manufacturers have recently developed means for utilizing waste heat from the engine-cooling water and

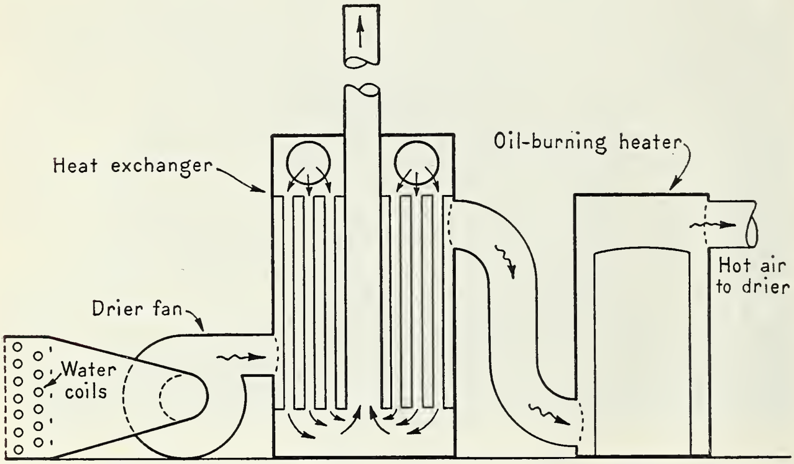

FIGURE 8.—Diagram showing method of obtaining heat for cotton drier from the cooling water and exhaust gases of internal-combustion engines and an auxiliary heater.

exhaust gases for cotton-drying in conjunction with the vertical drier. The heat recovered from the cooling water and exhaust of these engines is approximately two-thirds of that needed for cotton drying, and the additional heat needed is provided by means of a thermostatically-controlled oil-burning heater placed in series with the radiator and exhaust-heat exchanger in the engine room of the gin. In this way the steam boiler may be eliminated without introducing objectionable hazards. The gases from the engine exhaust and from the combustion chamber of the oil burner are passed through batteries of heater tubes. Figure 8 shows the arrangement diagrammatically. The fan may be driven by belt from the engine flywheel. Forcing rather than drawing the air through the heat exchanger and hot-air furnace lessens the fire hazard, as in case of leaks between the gas and the air compartments the pressure will cause air to flow into the stack and prevent hot gas getting into the drier. A further precaution against fire consists of placing a thermostatically-controlled temperature-limit switch in the flue of the hot-air furnace, limiting the gas temperature to 450° F.

STEAM-BOILER ACCESSORIES

INJECTORS AND FEED PUMPS

Steam boilers used only for drying purposes should be provided with means for supplying make-up or feed water. Injectors frequently are supplied with small boilers, but sometimes at critical periods they are difficult to operate and they are not suitable for returning hot water from the heater of the drier to the boiler unless a gravity return system is installed.

Regular high-pressure piston-packed feed pumps with single steam and water cylinders of the dimensions specified in table 2 are recommended. An air chamber is advisable on the pump discharge to eliminate water hammer. Where the heater cannot be installed above the boiler water line, it may be feasible to drain the hot condensate through a steam trap into a barrel set on a level slightly above that of the pump. If this is done, a gravity flow into the pump suction will allow the pump to return the hot water to the boiler and thus effect a saving of fuel over that required when the steam and condensate are wasted.

TABLE 2.—*Approximate minimum sizes of boiler feed pumps recommended for use with 30-horsepower steam boilers*

Item	Diameter of steam cylinder	Diameter of water cylinder	Stroke of pump	Size of steam pipe	Size of exhaust pipe	Size of suction pipe	Size of delivery pipe
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
With gravity return from heater to boiler [1]	2½	1⅜	2	¼	⅜	¾	½
Without gravity return from heater to boiler [2]	3	1¾	2½	⅜	½	1	¾

[1] Capacity of pump 0.013 gallon per stroke, for make-up water only.
[2] Capacity of pump 0.026 gallon per stroke, for all water used by boiler.

FUEL-OIL BURNERS

Where electricity is available for a cotton drier, motor-driven oil burners may be used, but where electricity is not available or is too costly an oil burner of the steam atomizing type may be used. Most ginning plants that are not electrically driven have facilities for storing compressed air to start the engines. Compressed air can be used with many forms of steam atomizing burners in starting the boiler before steam is available. Some ginners fire up their boilers with wood and then cut over to oil when sufficient steam-pressure has been generated.

The use of inexpensive fuel-oil burners that heat the oil in the burner body and then mix it with the steam at a special tip, is generally restricted to the better grades of fuel oil used in the oil engines of cotton gins. If the same oil can be used for both engine and boiler, the boiler burner may be supplied by a small drum placed upon a frame of its own and filled at intervals from the main supply.

HEATERS

There are certain basic requirements of a heater for seed-cotton driers, which differ from the requirements of heaters for other purposes because cotton driers are frequently forced to operate under a

wide range of atmospheric conditions and because the air which must be handled by the heater is often charged with dust, cotton fibers, and other foreign matter. Enough heating surface must be provided to offset the decrease in efficiency when the heating elements have become clogged with foreign matter, but not enough to cause excessive temperatures when the surfaces are clean or when steam pressures are increased. The volume of air to be handled by a heater depends to some extent on the method of feeding the drier (fig. 6), and the temperature of the air leaving the heater is affected by the temperature of the entering air, the working steam pressure, and the amount of dirt on the heating surfaces.

Well-established design practices favor limiting the velocity of air passing through an iron-pipe heater for seed-cotton drying to approximately 800 feet per minute. Therefore, to handle 4,000 to 5,000 cubic feet per minute as required for model A and model D installations, a heater should have 5 to 6 square feet of free area. For models B and C, the volumes to be heated are from 25 to 50 percent greater than for models A and D, because they are diluted with unheated air from the wagon telescope. Consequently, either a heater of larger cross sectional area must be used or the air velocity must be increased. Usually the latter is done, but the velocity should not be greater than 1,200 feet per minute.

IRON-PIPE HEATERS

Heat transmission per square foot of heating surface in iron-pipe heaters, with air velocities of 800 feet per minute, has been found in commercial tests to vary between 6½ and 10 British thermal units per hour per degree difference between the temperatures of the steam in the heater pipes and the air flowing through the heater. New heaters are more efficient than those which have become dirty, rusted, or encrusted with foreign matter, but it has been found that a coefficient of transmission of 7½ B. t. u. is dependable for cotton-drying calculations based on the entrance temperature of the air.

The load imposed upon the steam boiler by the heater for a seed-cotton drier seldom exceeds 600,000 B. t. u. per hour, especially when the condensation is returned directly to the boiler. With customary steam pressures of 100 pounds gage (temperature 337.9° F.) and the coefficient of transmission of 7½, the heating surface (S) required for the heater with air entering at 60° may be calculated as

$$S=\frac{600,000}{7\frac{1}{2}\times(337.9-60)}=288 \text{ square feet.}$$

A welded iron-pipe heating unit that may be either factory-made or home-made is shown in figure 9. This unit is two rows deep and has 38 square feet of effective heating surface. Eight of these units, with 304 square feet of heating surface, are recommended for drier model A or model D for a working steam pressure of 100 pounds gage, and 10 units with 380 square feet for a steam pressure of 60 pounds gage, with drier model A or D. For drier model B or C, 12 units with 456 square feet of heating surface are recommended for a working steam pressure of 100 pounds gage. These units can be constructed as shown in figures 9 and 10 by any competent welder, and

are simple, durable, and effective. Center distances and pipe spacings are alike for all banks of pipe, so that the heater may be cleaned from the sides and the front or back without difficulty. With good welding, such a heater may be used safely for working steam pressures as high as 200 pounds gage. The casing for this heater may be made of 2- by 8-inch dressed lumber and covered with galvanized iron, after assembly of the two-bank units. It should be close enough to the outside heating elements to prevent air blowing past without being heated. A side opening in the casing to permit cleaning the pipes is desirable.

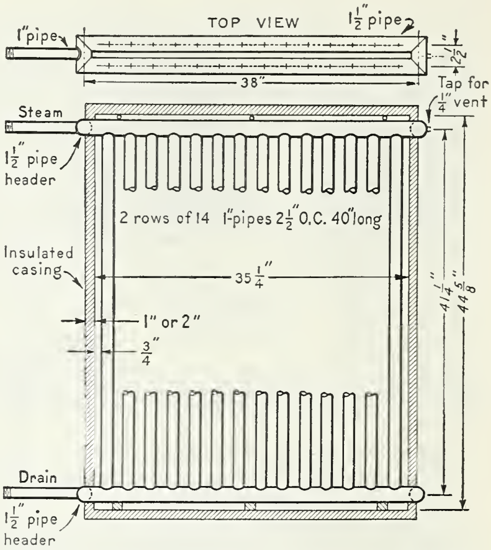

FIGURE 9.—Welded iron-pipe unit for heater for seed-cotton drier. (The top and sides of the insulated casing are built on the heater after the units are assembled.)

Where welding is not obtainable, a home-made heater may be constructed of return-bend pipe coils as illustrated in figure 11. The depth of a return-bend heater must be the same as described above for the welded unit, but the pipes must be horizontal instead of vertical and twice as many connections to steam and drain piping will be necessary. Each unit has the same heating capacity as the welded unit described above. Although this type of home-made heater coil is not so desirable as the welded unit, because of the greater possibility of leaks at the screwed joints, properly constructed heaters of this kind have given years of satisfactory service. After the units are assembled a covering of galvanized sheet metal is nailed on snugly to prevent leakage of hot air.

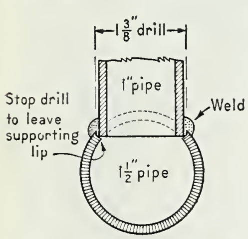

FIGURE 10.—Welded joint where heating pipe joins header.

It is advisable in iron-pipe heaters for use with seed-cotton driers to aline the pipes in straight rows both crosswise and lengthwise of the heater, to permit ready cleaning and inspection. Staggering of pipes is especially objectionable in heaters for cotton driers, because then the second as well as the first row becomes rather quickly covered with an insulating layer of lint, oil, dirt, and other foreign matter which destroys the efficiency of the heating surfaces. The staggering of the pipes also prevents access to all pipes behind the second row. The effectiveness of iron-pipe heaters is not appreciably improved by staggering the rows of pipes.

Iron-pipe heaters with cast-iron or steel bases have been on the market for a long time. They are usually made up in four-bank

sections, each having its own base and suitable tappings for steam supply, drain, and air venting. The three most commonly used forms of such heaters are illustrated in figure 12. The heavy weight of the sections is their principal disadvantage for cotton-drying purposes. If the rows of pipe are arranged so that they can be cleaned readily any of them may be used satisfactorily with any of the four drier models.

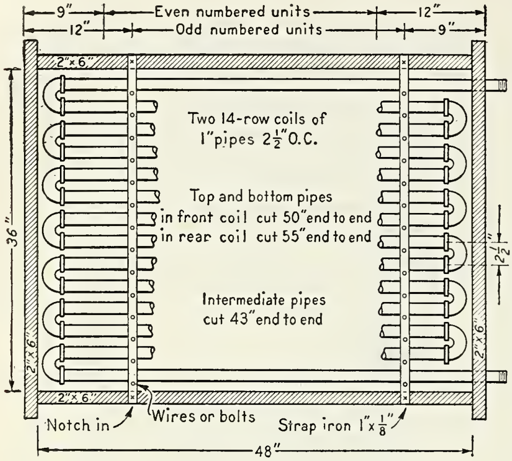

FIGURE 11.—Return-bend iron-pipe unit for heater for seed-cotton drier.

The approximate performance that may be expected with these units is shown in table 3, compiled from published data of heater manufacturers. Observations made on the performance of the welded and the return-bend heater coils shown in figures 9 and 11 have indicated responses to the variations in temperature of the entering air and in the steam pressure approximating those shown by factory-built iron-pipe heaters.

TABLE 3.—*Average effectiveness of factory-built iron-pipe heaters, open-area type, of 1-inch pipes spaced 2⅝ inches on centers, with air entering at 60° F. and flowing through heater at 800 feet per minute* [1]

Steam		Temperature of air leaving heater		
Gage pressure (pounds)	Temperature	16 banks of pipes	20 banks of pipes	24 banks of pipes
	° F.	° F.	° F.	° F.
40	286.7	165	181	194
60	307.3	175	193	206
80	323.9	185	203	218
100	337.9	193	211	227

[1] This table may be used also for the heaters shown in figs. 9 and 11.

FIN-TYPE HEATERS

With drier models A, B, and C, fin-type heaters instead of iron-pipe heaters may be used if they are properly screened so they do not have to handle air that is heavily charged with dust and other foreign matter. They are not suitable for use with model D, which uses the exhaust of the cotton unloading fan for drying the cotton.

Fin-type heaters, usually made of copper tubes with helical fins, can be purchased and installed for approximately the same cost as equivalent-capacity iron-pipe heaters. Two factory-made heaters of this type, one having vertical tubes and the other having horizontal tubes, are shown in figure 13. One bank of fin tubing is generally

considered to be as effective as four banks of 1-inch iron pipe in heater frames of the same cross section. Purchase specifications therefore should allow one row of fin tubing for each four rows of iron pipe

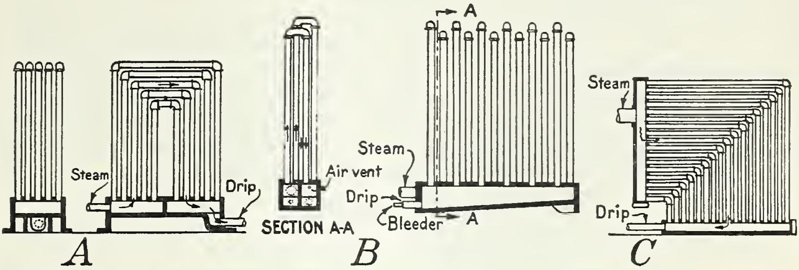

FIGURE 12.—Factory-built iron-pipe heaters: *A*, Open area; *B*, return bend; *C*, miter.

indicated in table 3, for approximately the same gross face area and the same air velocity through the heater.

Because fin heaters are difficult to clean, they must be protected with a fine screen, the net free area of which should be slightly greater

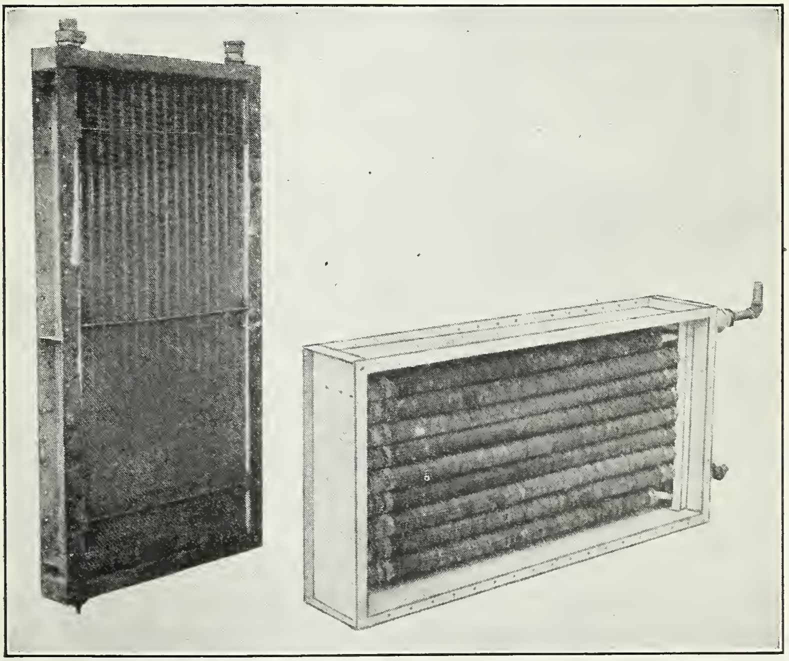

FIGURE 13.—Factory-built fin-type heaters suitable for model A, B, and C cotton driers.

than the gross face area of the heater. It is recommended that 14-mesh window screen supported upon heavier hardware cloth be used with these heaters for cotton drying.

LOCATION OF HEATER

The heater for the cotton drier should be located above the water line of the steam boiler and as close to the separator and the top of the

drying tower as possible. The resistance imposed by the check valve in the drain line from the heater requires a head of at least 2 feet in order that the condensation shall flow freely through the check valve. It is therefore necessary that the heater be 2 feet or more above the water line of the boiler; the circulation is improved as the distance above the water line is increased. Traps and pumps are seldom necessary where a gravity return system has been properly installed.

Placing the heater close to the top of the drying tower shortens the hot pipe between the damp-cotton inlet and the top of the tower, and thus reduces the loss of heat and the consequent drop in temperature of the heated air conveying the cotton through the drier.

VALVES AND PIPING

The individual units or sections of heaters may be controlled by separate valves, or the entire heater may be regulated by single

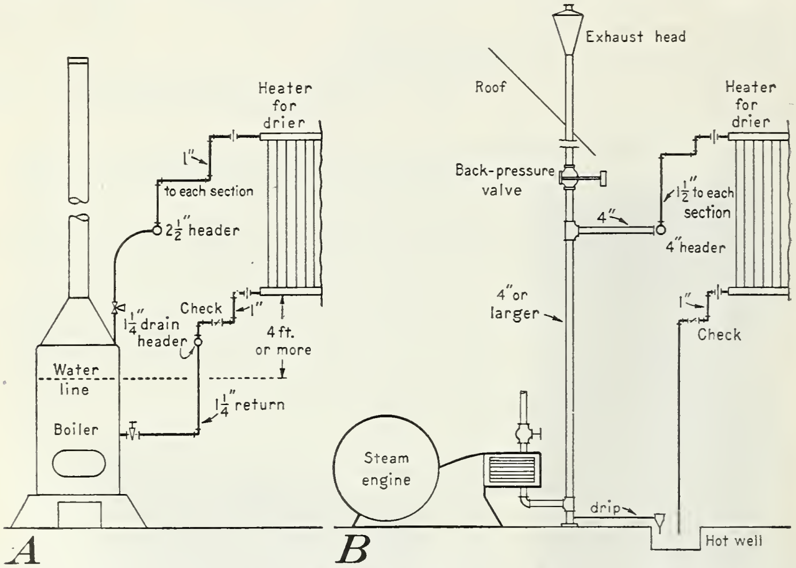

FIGURE 14.—Steam supply and drain piping for heaters for seed-cotton driers for: *A*, High-pressure steam supply, suitable for ginning plants powered by electric motors or Diesel engines; *B*, low-pressure steam supply from engine exhaust, suitable for ginning plants powered by steam engines.

supply and return valves. Although better control is obtained by the former system, very satisfactory results have been obtained from the use of single valves.

Manually controlled valves in general have proved to be more economical and satisfactory than so-called "thermostatic regulation" in cotton-drying installations. For a heater upon a platform above the ginning or operating floor, extension handles or reach rods may be readily installed on manually controlled valves.

Swing joints, properly made, are preferable to rigid piping connections between the headers and the heater. The steam supply or steam header pipe is usually 2½ inches in diameter, the condensation drain or return header pipe should be 1¼ inches in diameter, and the air vent or vent header should be of 1½-inch pipe if an automatic thermostatic air-vent valve is to be used.

The high-pressure and low-pressure forms of piping connection for welded iron-pipe units shown in figure 14 may be applied with slight modifications to return-bend coils or to fin-type heaters. Air-vent piping is not shown on this diagram, but should be installed to prevent the heater from becoming air-bound. All piping between the boiler and the heater should be covered.

A combination of high-pressure and low-pressure piping to the heating units may be readily accomplished where there is insufficient exhaust steam to supply the entire heater. Two or more banks of pipes may be supplied with the high-pressure steam independently, the remaining units being connected only to the exhaust steam. Such an installation should not materially overload the boiler and is more economical than the use of high-pressure steam alone.

OPERATION OF THE VERTICAL DRIER

Before beginning the season's operation, a test run should be made to determine that sufficient air is blown through the drier to convey the cotton readily. Before commencing a day's run, it is advisable to operate the drying fan for at least 5 minutes so that the tower will be heated and ready to receive the first load of cotton. The piping should be connected during this warming-up of the drier, so that all piping between the drier and the ginning system is warm when drying begins.

All heater screens should be cleaned daily. If this is not done the quantity of air will be reduced to a point where the drier will not operate satisfactorily.

Variation of the steam pressure between 50 and 100 pounds will not hinder nor appreciably affect the drying operations, hence it is not necessary to fire the boiler at any set pressure or to insist upon having the highest limits at the coils. It is desirable, however, to maintain a fixed pressure and a constant temperature during operation.

The most effective rate of feeding the drier is that which will supply the gin stands yet avoid an accumulation of surplus seed cotton at the overflow of the distributor, because this surplus may again become damp and because it entails additional expenditure of labor and power for rehandling.

It is well to inspect incoming loads of seed cotton, and adjust drying temperatures to the individual requirements of each load. This can be easily accomplished with a little practice, and will aid in obtaining economical drying and ginning.

SPECIAL INSTALLATIONS

IN AN OCTAGONAL COTTON HOUSE

An effective adaptation[5] of the vertical drier to an octagonal cotton house in South Carolina is shown in figure 15. Cotton growers engaged in seed breeding or special handling of seed for planting purposes may use this method to advantage for improving the germination qualities of the seed[6] by the Government process of drying the seed cotton. An obvious advantage of this installation is that seed cotton may be dried during transfer either from wagon to bin or from bin to bin, when dampness or a tendency to heat has been observed.

[5] Developed by J. T. Banks and David R. Coker cooperating with the Department of Agriculture.
[6] GERDES, F. L., and BENNETT, C. A. See footnote 3.

COMBINED WITH FARM STORAGE

The combination of cotton driers with farm storage and farm ginning facilities affords special advantages, in some instances, by permitting damp pickings to be stored in threatening weather or while awaiting ginning. Figure 16 shows a satisfactory installation of this type in the northern part of the Mississippi Delta, using a model B drier. When seed cotton is stored for night ginning or to avoid exposure to bad weather, the heater may be used without the drying tower if only small drying effect is desired. Similarly, cotton may be transferred from bin to bin either with or without heat, and may be taken to the cotton gin either through the drier or directly from the bins. An appreciable degree of cleaning is obtained when storing

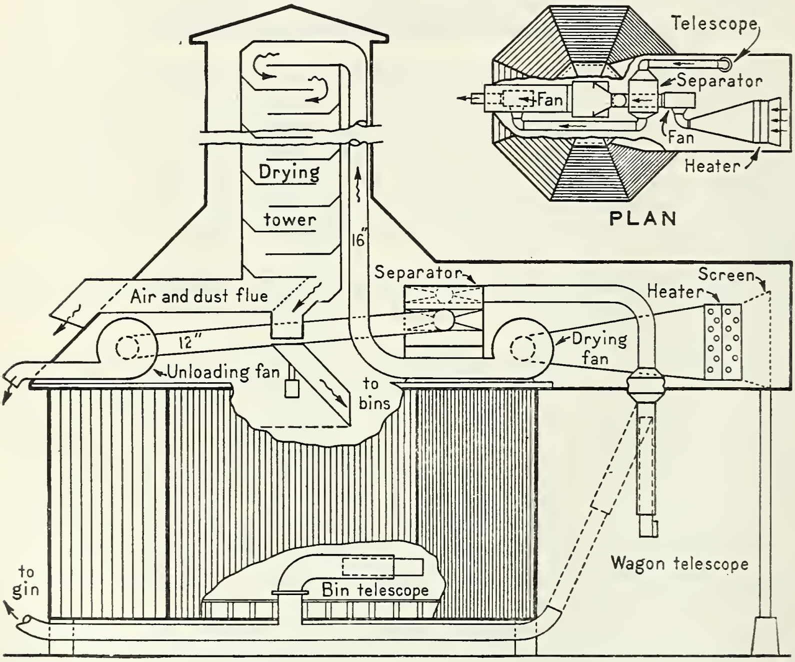

FIGURE 15.—Vertical drier in an octagonal cotton house.

cotton with this installation by discharging the cotton against vertical screens in the monitor walls above the bins.

COTTON DRYING WITH HEATED DOFFING JET IN AIR-BLAST GINS

Reducing the relative humidity of the doffing jet in air-blast gins to less than 40 percent has been found to overcome certain difficulties that frequently arise in ginning wet cotton with air-blast gins during damp weather. By using a warm, dry doffing jet the saw cylinder is kept dry and clean and the tendency for the wet or damp cotton fibers to cling to and choke the saw teeth is overcome. A public patent [7] has been obtained upon the method of improving air-blast

[7] BENNETT, C. A. A PROCESS AND METHOD FOR GINNING COTTON WITH AIR-BLAST GINS. U. S. Patent No. 1,827,183; filed Apr. 10, 1930; issued Oct. 13, 1931. U. S. Patent Office Off. Gaz. 411:419–420, illus. 1931.

ginning by employing a hot blast through the nozzles in order to reduce the relative humidity of the doffing volume to less than 40 percent.

The steam service to a heater of the seed-cotton drier may be extended to a similar heater for the air blast of the gin. Eight banks of 1-inch iron pipe of the type of heater shown in figure 9 are needed to obtain a temperature of 150° F. with a velocity through the heater of 1,200 feet per minute, which is required for five 80-saw gin stands. The inlet of the casing for this heater should be flared out 30° with the center line enough to permit using a fine screen of adequate area, and for connection to the air-blast fan should be flared in 30° with the center line to the size of the fan inlet, in order to obtain efficient entrance and uniform flow of air.

This heated doffing jet should be used only when ginning very damp or wet cotton, and the temperature must be barely sufficient to obtain

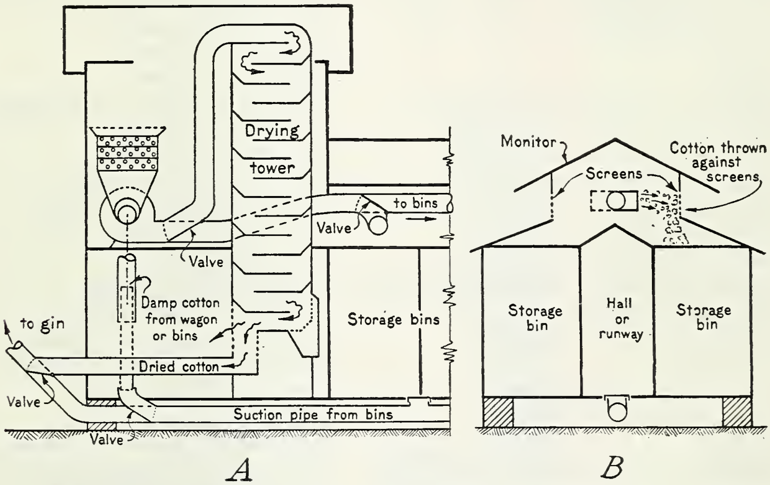

FIGURE 16.—A vertical seed-cotton drier combined with farm storage and ginning: *A*, Side; *B*, end.

the desired relative humidity of the jet. A temperature of 120° F. or less usually has been found adequate.

SEED-COTTON DRYING AND COTTONSEED STERILIZATION

The cotton ginning plant equipped with a drier can be equipped on short notice to combat seed infestation by means of steam sterilizing. Effective seed sterilization is being accomplished in Arizona New Mexico, and Texas by discharging jets of live steam into steam-jacketed spiral or screw conveyors. A 5-minute period of sterilization at 200° F. is specified for pink bollworm infestations of cottonseed.[8] The capacities of most steam boilers for cotton drying are generally ample for sterilizing up to 2½ tons of cottonseed per hour if no drying is attempted at the same time. Approximately 30 boiler horsepower is an average rating for standard vertical seed-cotton drier installations, and thus will be adequate for the sterilizing outfits in Texas, New Mexico, and Arizona of which few are rated at more than 20 boiler horsepower.

[8] SASSCER, E. R. PINK BOLLWORM AND MEASURES TO EXCLUDE IT. U. S. Dept. Agr. Yearbook 1926: 582–584, illus. 1927.

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